Curricula for M.Tech. in Renewable Energy Offered by
Department of Chemical Engineering June 2017
### Semester 1

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Chemical Engineering

ECH. PROGRAMME IN RENEWABLE ENERGY OFFERED BY CHEMICAL ENGINEERING

SYLLABUS June 2017
Semester I

THEORY
Subject Name: Energy Resources

Paper Code: REEN5101

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Module 1: [10L]
Energy: Basic concepts and various forms; Fundamental of Renewable and Non-Renewable Energy Sources; Energy and Environment; Renewable Energy Resources and Present Energy Scenario in India; Sustainability of Development with Renewable Energy Resources; Basic Heat Transfer Mechanisms, Energy and Momentum Conservation Principles and Bernoulli’s equation.
Inter-conversion of various forms of Energy and their utilisation in the appropriate perspective.

Module 2: [10L]

Module 3: [10L]
Biomass; Biofuels and Biogas: Introduction; Renewability and Sustainability of Bio-Energy Resources; Origin of Biomass: The photosynthetic process; Biomass Resources; Direct Use as Energy Resources, Biofuel production Processes; Biogas Production Processes; Alcoholic Fermentation and Alcohol blending with Gasoline for saving fossil fuel; Biodiesel Production through Transesterification of Vegetable oils and Fats; Hydro Power generation: Introduction; Classification of Water Turbine; Theory of Turbo- Machineries; Jet Velocity. Angular Velocity; Hydroelectric Systems: Essential Components and their Overall efficiencies; Merits and Demerits of Hydroelectric Systems; Hydraulic Machines; Status of Hydro-Power in the Indian Scenario.

Wind Power: Introduction; Origin and Global Distribution of Wind; Turbine Types and Terminologies, Aerodynamic principles in Wind Power Generation; and Wind Turbine Generators and their Applications;
Module 4: [10L]


Ocean Thermal, Tidal & Wave Energy, Human & Animal Power Conversion Systems
Environmental Impact of Renewable Energy Harvesting Processes and Natural Energy Cycle- Contradictions
Energy Analysis from different types of Energy Resources, both Renewable and Fossil

Text Books:

Reference Books:
Module 1: [10L]
Introduction: Sources of renewable energy – solar energy. Earth sun energy flux diagram, overview of renewable energy, energy conversion, energy resource assessment: solar, solar thermal collectors, low temperature systems, solar heat pumps & refrigeration, concentrating collectors, overview of solar thermal power systems, photovoltaic energy conversion.

Module 2: [10L]

Module 3: [10L]

Module 4: [10L]
Solar thermal applications: Temperature & choice of collectors, swimming pool heating, domestic and process heat, characteristic equation, mathematical modelling, simulation, storage tank; (pressurized vs. non pressurized), storage with stratification, storage tank with gas as auxiliary, heat exchangers, corrosion and antifreeze, dimensioning, connecting pipe circuit, expansion tank sizing, concentrating collectors, process heat, air heating collectors, solar drying, solar distillation.
Text Books:

Reference Books:
Module 1: [10L]
Review of vectors and tensors, Transport Theorem, introduction to momentum transfer, concept of continuum, viscosity and mechanisms of momentum transport, momentum flux, Newton’s law of viscosity, shear stresses during laminar flow, Non-Newtonian fluids-Bingham model, Ostwald-de- Waele model, Eyring model, Reiner-Philippoff model, convective momentum transport, shell momentum balances and velocity profiles in laminar flow between flat plates, rectangular channels, circular tubes and pipes, annulus, flow around a sphere, continuity equation for both Newtonian and non-Newtonian fluids, flow of falling films with constant and variable viscosity, equations of continuity in Eulerian and Lagrangian form, equations of motion-Euler and Navier Stokes(rectangular, spherical and cylindrical coordinates), control volume approach, applications of these equations in steady and unsteady state problems, unsteady state laminar flow of Newtonian fluids in various geometries, concept of stream function and velocity potential, boundary layer theory (one and two-dimensional), velocity distributions in turbulent flow through ducts and circular tubes, momentum flux, application of Prandtl mixing length to turbulent flow, concept of Reynold’s stresses, eddy viscosity, Reynold’s averaged Navier Stokes equations, interphase transport, and concept of friction factor during flow through tubes, packed beds etc.

Module 2: [10L]
Modes of heat transfer, heat flux and Fourier’s law of heat conduction, concept of thermal conductivity and diffusivity, shell energy balances and boundary conditions: heat sources: electrical, nuclear, viscous, chemical. Steady state heat conduction(one and two-dimensional) without heat generation for systems of different geometries e.g. composite walls, cylinders, spheres, having constant and variable thermal conductivities, conduction with generation: Poisson equation, conduction with temperature dependent generation, unsteady state heat conduction in finite and semi-infinite slabs (concept of distributed parameter and lumped parameter system)

Convection and Newton’s law of cooling, heat transfer coefficient, different boundary conditions in the energy equations, cooling of a solid(lumped parameter system)forced and free convection, transpiration cooling, viscous flow and development of boundary layer, heat transfer in laminar flow through a tube, natural convection on a vertical plate, turbulent heat transfer in channels
and pipe, temperature distributions in turbulent flow, temperature profiles near walls, turbulent heat flux, heat transfer through fins, countercurrent heat exchangers, boiling systems: Pool and nucleate boiling, condensation, phase change, Interphase energy transport, heat transfer coefficients, forced convection in tubes, around submerged objects and packed beds
Radiation Energy transfer: Properties of radiation, absorption, emission, and black body, properties of radiating surface, black body radiation: Plank’s distribution law. Total emissive power: Stefan-Boltzman law, Wien’s displacement law; Kirchoff’s law; emissivity of black body, gray body and real body; radiation between surfaces: view factor, radiation heat exchange for three radiating surfaces; radiation heat transfer through absorbing emitting medium

Module 3: [10L]
Introduction to fundamentals of mass transfer, molecular mass transport, concept of diffusivity, Fick’s law of diffusion, diffusion through stagnant gas film, falling film, diffusion with heterogeneous chemical reaction, equation of continuity for binary mixture, mass and molar transport by convection, concentration distributions in laminar flow, shell mass balances, boundary conditions, applications of diffusive transport with or without chemical reactions, absorption with or without chemical reaction, concentration distributions during unsteady state mass transport, steady state boundary layer theory for mass transport during flow through various geometries, concentration distributions in turbulent flow, interphase mass transport, concept of mass transfer coefficient, applications, mass transport in porous media and concept of Knudsen diffusion, mass transport across selectively permeable membranes, general advection-diffusion equations.

Module 4: [10L]
Analogies among momentum, heat and mass transfer, dimensional analysis, derivation of important dimensionless groups and significance of dimensionless groups in momentum, heat and mass transport, simultaneous mass, heat, momentum transfer and their industrial applications, e.g. applications of momentum heat and mass transport concepts for detailed design and analysis of cooling towers, distillation columns, absorbers, reactors, dryers, application of energy balance in solar cells, fuel cells, biogas generation etc, case studies of several plants e.g. thermal power plants, refineries, petrochemical industries, pharmaceutical industries, textile industries, desalination plants, effluent treatment units.

Text Books:

Reference Book:
5. Advanced Transport Phenomena, J.C. Slattery, The Press Syndicate of the University of
M. Tech in Renewable Energy

Cambridge
Subject Name: Materials for Energy Conversion Systems

Paper Code: REEN5104

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Module 1: [10L]
Device fabrication technology: Diffusion, Ion Implantation, Etching, oxidation, photolithography, sputtering, physical vapour deposition (PVD), Chemical Vapor deposition(CVD), Plasma enhanced CVD (PECVD), Hot wire CVD (HWCVD), etc. Spectral response of solar cells, quantum efficiency analysis, dark conductivity, crystalline silicon deposition techniques, I-V characterization. Introduction to material characterization: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), X-ray diffraction (XRD), Raman spectroscopy, Atomic force microscopy (AFM).

Module 2: [10L]
Introduction to physics of semiconductor devices and basics of solar cells, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, Concepts on high efficiency solar cells, III-V high efficiency solar cells, tandem and multi-junction solar cells, Solar PV concentrator cells and systems, III-V, II-IV compound materials thin film solar cells, Nano, micro and poly-crystalline Si for solar cells, mono-micro silicon composite structure, material and solar cell characterization, PERL (passivated emitter with rear locally diffused) Si solar cell.

Module 3: [10L]
Advanced solar cell concepts and technologies (Porous Si layer transfer, metal induced crystallization etc.) Amorphous silicon thin film technologies, multi junction tandem solar cells, stacked solar cells. HIT Solar cells, 3rd Generation Solar cells based on Nano- materials.

Module 4: [10L]
Text / Reference Books:

Subject Name: Design of Heat Transfer Equipments

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Module 1: [10L]
Fundamentals of heat transfer: steady state heat conduction through plane wall, composite wall, heat transfer resistance in series and parallel, conduction with heat generation, convective resistance, critical insulation thickness, steady state heat conduction through extended surface, fin efficiency, dimensionless number for convection, empirical correlation for free and forced convection. Correlation of heat transfer coefficient for condensation and boiling.

Module 2: [10L]
Classifications of heat exchangers, overall heat transfer coefficient, LMTD and LMTD correction factor, fouling factors, Effectiveness and number of transfer unit of heat exchangers, sizing and rating problems of heat exchanger design. Flow and stress analysis: Effect of turbulence, friction factor, pressure loss, stress in tubes, header sheets and pressure vessels design, thermal stresses, shear stresses - types of failures.

Module 3: [10L]

Module 4: [10L]
Types of Compact heat exchanger, merits and demerits, design of compact heat exchangers, plate type heat exchangers, performance influencing parameters, limitations, Design of surface and evaporative condensers, cooling tower, performance characteristics.

Text/Reference Book:
Module 1: [10L]
Meaning of Research, Types of Research, process of Research, Formulation of Research Problem and Development of Research Hypotheses, Data Collection — Primary and Secondary Data, Types of Measurement Scale, Sample Designing, Sampling vs. Non sampling Error, Different types of Sample designing, Determination of Sample Size, Testing of Hypotheses, Null and Alternate hypothesis, One tailed and two –tailed test, Type I and Type II error, Steps in Testing Hypothesis, Level of Significance and Critical region, Z test, t Test, P Test, ANOVA, Correlation and Regression Analysis, Chi – Square test.

Module 2: [10L]

Module 3: [10L]
Project Appraisal: DPR - Technical, Marketing, Environment, Social, Financial Appraisal [Non Discounted Cash Flow Technique like Payback and Accounting Rate of return (ARR); Discounted Cash Flow technique like Profitability Index (P/I) or Benefit Cost ratio (BCR), Net Present Value (NPV), Internal Rate of return (IRR)]

Module 4: [10L]
Project Planning, Work Breakdown Structure (WBS), Networking Concepts, Network Analysis, Difference between PERT and CPM, Calculation of Floats, Concept of Crashing, Gantt Chart, LOB.
Case Study on Project Management

Text/ Reference Book:

LABORATORY
Subject Name: Solar Laboratory

Paper Code: REEN5111

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Experiments:

*At least any five experiments are to be carried out by students*

1. Solar radiation measurement
2. Figure of Merit measurement of solar cell
3. Impact of Figure of Merit on energy output of solar cell
4. Characteristics of storage battery
5. Characteristics of power conditioning unit
6. Development of material for energy storage component
7. Development of black coating for solar thermal application
Subject Name: Energy Devices Laboratory

Paper Code: REEN5112

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Experiments:

At least any five experiments are to be carried out by students

1. Introduction to material characterization: Scanning electron microscopy (SEM)
2. Transmission electron microscopy (TEM)
3. X-ray diffraction (XRD),
4. Chemical vapor deposition (CVD),
5. Fabrication of Solar cell in virtual wafer fabrication lab
6. Study of 100KW PV power plant, (Roof top of A & B Building)
Subject Name: Seminar -I

Paper Code: REEN5121

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A Seminar topic will be allotted to individual student according to his/her subject of interest. A thorough report should be prepared based on which seminar presentation and question-answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question-answer session and the report submitted.
Semester II

THEORY
Subject Name: Process Modelling and Simulation in Energy System

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Module 1: [10L]
Introduction to system. Deterministic process and stochastic process, Concept of Physical modeling and mathematical modeling. Uses of mathematical models in Chemical Engineering, Concept of simulation and process analysis.

Lumped and distributed parameters models. Modeling of simple hydraulic tank, enclosed vessel, mixing vessel, simultaneous mass and energy balance, Continuous heating in a stirred tank using jacket and using coil. Modeling of cone-shaped tank.

Module 2: [10L]

Module 3: [10L]

Module 4: [10L]
Basic Modeling of Alternate energy systems – Energy balance equations used in modeling Solar Thermal domestic hot water system and single Solar PV cell; Mass transfer models used in fuel cell – Fickian, Stefan–Maxwell and Dusty Gas Model for porous media and in porosity free domain.

Text/ Reference Book/ Literature:

3. Fuel Cells: From Fundamentals to Applications - Supramaniam Srinivasan –Springer
Subject Name: Advanced Engineering Thermodynamics

Paper Code: REEN5202

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Module 1: [10L]

Module 2: [10L]

Module 3: [10L]
Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases- Reduced properties-Compressibility factor-.Principle of Corresponding states. - Generalised Compressibility Chart and its use-. Maxwell relations, Fundamental property relations, Throttling and Joule-Thomson Coefficient, Clausius Clapeyron equation. Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction.

Thermochemistry: Enthalpy, Heat of reaction at constant pressure and volume, Hess’s Law of constant heat summation , reaction equilibirum, temperature pressure effect on reaction equibrium, Heat of combustion, Adiabatic flame temperature, material and energy balance of combustion reaction.
Module 4: [10L]
Vapor Power cycles: Carnot vapor cycle, Rankine cycle, comparison of Carnot and Rankine cycle, calculation of cycle efficiencies, variables affecting efficiency of Rankine cycle, reheat cycle, regenerative cycle, reheat-regenerative cycle, Gas Power cycles: Otto and Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles, air standard efficiency, mean effective pressure, brake thermal efficiency, relative efficiency, Brayton cycle, effect of reheat, regeneration, intercooling and turbine and compressor efficiency on Brayton cycle, Vapor compression Refrigeration cycle, COP of refrigeration cycle

Text/Reference Book:
1. Engineering Thermodynamics by P.K. Nag, McGraw-Hill Education
2. Fundamentals of Thermodynamics by Borgnakke & Sonntag, 7th Ed. Wiley India (P) Ltd.
3. Thermodynamics – An Engineering Approach by Yunus Cengel & Boles, McGraw-Hill Education
4. Engineering Thermodynamics by Gordon Rogers and Yon Mayhew, Pearson Education Ltd.
Module 1: [10L]
Wind Energy: Sources and potential; Wind turbines-Site location, aerodynamics, types and construction fundamentals; Wind Energy Conversion Systems; Wind-Diesel hybrid systems; Wind-energy storage; Environmental aspects
Geothermal Energy: Sources and potential; Origin and Distribution; Hydrothermal Resources-Vapour dominated System, Liquid dominated system, Geo-pressed resources, Hot Dry Rock Resources; Analysis of geothermal resources-Hot Dry Rock Resource, Hot Aquifer Resource; Exploration and development; Environmental aspects; Potential in India.

Module 2: [10L]
Tidal Energy-Origin and Nature; Limitations; Tidal Range Power; Conversion Schemes; Present status; Environmental impacts Wave Energy-Power in waves; Wave Energy Technology-Heaving Float type, Pitching type, Heaving and Pitching-float type; Present status and Environmental impacts Ocean Thermal Energy-Origin and characteristics; Ocean Thermal Energy Conversion technology; Present status and Environmental impacts

Module 3: [10L]
Macro Hydel Power - Characteristics of hydropower plants ; Demand profiles and System considerations; Mathematical modelling of hydropower systems; Theory of hydraulic design and hydraulic turbines —Selection of turbine types , Francis turbines, Pelton turbines, Kaplan turbines; Efficiency measurements, Regulators and load control, Valves and gates, Auxiliary equipment; Design strategies for hydraulic structures— Headworks and intakes, Spillways and outlets, Penstocks and conduits
Mini Hydel Power - Advantages and disadvantages; Layout of a Micro-Hydro Scheme; Water turbines-classification, characteristics and selection; Generators; Present status and environmental impacts

Module 4: [10L]
Magneto-Hydrodynamic (MHD) Power Conversion-Basic principle; MHD generator; MHD systems; Present status and Potential
Thermo-electric and Thermonic Power Conversion Systems-Basic principle; Present status and Potential Fuel Cell (FC)-potential applications; Classification; Types-PAFC, AFC, PEMFC, MCFC, SOFC; Fuel Cell development stages and relative performance; Fuels for FC; Efficiency and VI characteristics; FC power plant; Present status and environmental Impacts
Hydrogen Energy-potential applications; Production methods: thermo-chemical, electrolysis, thermolysis, bio-photolysis; Storage and Delivery; Conversion; Safety Issues; Present status
Text Book:
2. Renewable Energy Resources Twidell & Wier, CRC Press (Taylor & Francis)

Reference Book:
1. Renewable Energy Resources-Tiwari & Ghosal, Narosa Publishers
2. Renewable Energy Technologies-Ramesh & Kumar, Narosa Publishers
4. Renewable Energy Sources and Emerging Technologies-Kothari & Singhal, Prentice Hall of India
Subject Name: Foundation Course on Finance, Economics & Marketing

Paper Code: HMTS5201

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Module 1: [10L]
Introduction, Scope & Objectives of basic financial concepts – Interference of Finance Department with other areas of business; Time value of money and Cost of Capital; Project Appraisal - Pay-back period, Internal Rate of Return, Net Present Value, Cost-Benefit Analysis; Sources of Finance - Internal and External – Short Term & Long Term – Securities, Debentures/bonds & Shares; Financial Institutions & Markets – Primary & Secondary Market, Money and Capital Market

Module 2: [10L]

Module 3: [10L]

Module 4: [10L]

Text/Reference Book:
1. Financial Management: Theory and Practice; Prasanna Chandra, McGraw Hill.
3. Managerial Economics by Suma Damodaran; Oxford University Press.
Subject Name: Measurement and Control for Energy System

Paper Code: REEN5241

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Module 1: [10L]
Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, correlation, estimation of uncertainty and presentation of data, design of experiments – Experimental design factors and protocols

Module 2: [10L]
Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow rate, thermo-physical and transport properties of solids liquids and gases, radiation properties of surfaces, vibration and noise - Computer assisted data acquisition, data manipulation and data presentation

Module 3: [10L]

Module 4: [10L]
Process characteristics, Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - Continuous, Discontinuous and Composite control modes – Analog and Digital controllers

Text/Reference Book:
2. W. Bolten, Industrial Control and Instrumentation, University Press, 2004
4. S.P. Venkateshan, Mechanical Measurements, Ane Books Pvt Ltd, 2010
Subject Name: Energy & Environmental Impact Analysis

Paper Code: REEN5242

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Module 1: [10L]

Air pollution aspects from conventional power plants, Sampling and analysis of air pollutants, Green house effect and global warming, Carbon foot print, general discussion on its reduction by the use of renewable energy devices.

Module 2: [10L]
Problems of water pollution in renewable energy industries. Effluent treatment plant, trickling filter, RBDC and RBRC, oxidation ditches, WSP, Root zone and Reed bed treatments. Combined Sewage & Effluent treatment plant along with canteen waste for bio-gas generation.

Module 3: [10L]

Module 4: [10L]

Text/ Reference Book/ Literature:
4. www.wbpcb.gov.in
Module 1: [10L]
Introduction to biomass; Basic photosynthesis process: C3 and C4 plants on biomass production; classification of biomass; conversion of biomass into fuels; physicochemical characteristics of biomass as fuel; CO₂ fixation potential of biomass, Biomass resource assessment, application of remote sensing for resource assessment; biomass productivity study, energy plantation; basis of selection of plants for energy plantation; potential of biomass as energy sources: Worldwide and India.

Module 2: [10L]
Anaerobic digestion, biogas production mechanism and technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants, biogas slurry utilization and management, biogas applications, cost benefit analysis of biogas for cooking, lighting, power generation applications, Feedstock for biogas, Microbial and biochemical aspects, operating parameters for biogas production. Kinetics and mechanism, Bio-hydrogen production: hydrolysis, fermentation.
Landfills: Gas generation and collection in landfills, Introduction to transfer stations. Comparison with non-energy options like Vermiculture, Composting, and case studies.

Module 3: [10L]
Bio-fuels different processes of production, different generation of bio-fuel: based on raw material used. Biodiesel production, different types of raw materials, non-edible oil-seeds, Pyrolysis, mechanism of transesterification, fuel characteristics of biodiesel; Alcohol production: types of raw materials, lignocellulosic biomass for alcohol production, process description, distillation etc.

Module 4: [10L]
Introduction to bioreactor, anaerobic digesters, fluidized bed, airlift reactor, conversion devices: combustors (Spreader Stokes, Moving grate type, fluidized bed), gasifier, digesters. Briquetting technology: Production of RDF and briquetted fuel. High rate digesters for industrial waste water treatment, Photo-bioreactors: raceway pond, tubular, flat panel, helical etc. numerical problems
Text/Reference Book:

1. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984.
7. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S
LABORATORY
Subject Name: Non-Solar Laboratory

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Experiments:

*At least any five experiments are to be carried out by students*

1. Experiments on biomass gasification
2. Extraction of Bio-oil from biomass feedstock
3. Development of fuel characteristics from bomb calorimeter.
4. Characterization of energy from waste
5. Experiments on biomass resource assessment
6. Measurement of figure of merit of Wind Energy
SESSIONAL
Subject Name: Internship

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Students will be sent for training to an industry for a period of 4 to 6 weeks after completion of 1st Semester examination. After completion of the training the students will submit a comprehensive report consisting of general overview of the plant, process description with process flow diagram, details of different equipments with specifications, process instrumentation and control, product with production capacity, raw materials utility and energy consumed per unit of product. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and training coordinator with Head of the Department as Chairman during 2nd Semester examination.
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A Seminar topic will be allotted to individual student according to his/her subject of interest. The seminar topic must be different from the topic already presented in Seminar-I. Topic of the seminar should not be on internship training. A thorough report should be prepared based on which seminar presentation and question-answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question-answer session and the report submitted.
Semester III

THEORY
Subject Name: Energy Management and Audit

| Paper Code: REEN6101 |

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Module 1: [10L]

Module 2: [10L]
Procedures and Techniques:
Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering.
Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation.
Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation.
Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation.

Module 3: [10L]
Energy Policy Planning and Implementation:

Module 4: [10L]
Energy Balance & MIS:
First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Identification of losses,

**Energy Audit Instruments:** Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy

**Text/ Reference Books:**
1. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
Subject Name: Renewable Energy III

Paper Code: REEN6102

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Module 1: [10L]
Water Resources & Hydro Planning: Categorization, development and purposes of water resources, Classification of hydro projects, Small Hydro Power (SHP) development and its relevance, allotment of sites, opportunities; hydropower planning on existing structures and new sites; Different methods for stream gauging, rainfall, runoff and its estimation by different methods, peak flood estimation, demonstration of discharge measuring instruments; Flow duration studies, assessment of power potential and optimisation of installed capacity; Topographical, geological and power evacuation surveys and investigations, demonstration of surveying instruments, site selection for SHP and other projects; Financing of projects, cost estimation for different components, financial and economic analysis, valuation of Hydro Assets, clean development mechanism, management of Hydro plants.

Module 2: [10L]
Design of SHP and other Hydro Structures: Hydraulics and structural designs of civil works, national and international standards and codes of practice, diversion works and intake structures, site selection, innovative designs; Power house layouts, channel (lined and unlined), under drainage works, tunnels and tail race channel; Sediment properties and transport, desilting devices, silt disposal; Cross drainage works; Balancing reservoir, spillway and forebay tank; Penstock, anchor block and saddle, surge tank; Power house buildings, material handling, machine foundation, Seismolgical consideration.

Module 3: [10L]
Electro Mechanical Hydro Equipments: Types, characteristics and testing of ac generators; Sizing and specification of single and three phase generators; Power factor and its correction methodologies, excitation systems; Electro-mechanical and digital governor, electronic load controller; Types of relays, contactors and control schemes for hydro stations; Supervisory control and data acquisition (SCADA), integrated computer control system; Switchyard equipments, power and instrument transformers, circuit breakers, bus-bar; Protection schemes for generator, transformer and bus-bar, design of circuit diagram for auxiliary and grounding systems.

Module 4: [10L]
Classification and working principles of hydro turbines, different components of impulse and reaction turbines; Design concepts of hydro turbines, pump-as-turbine and other non conventional hydro turbines; Characteristics of hydro turbines, geometric similarity, main characteristic and operating characteristic curves, hill curves; Governing of hydro turbines.
Mechanical and electro-mechanical governors, electronic load controller, mechanical drives, gear box, pulleys; Selection of hydro turbines; Classification, components and selection of gates and valves; Model testing of hydro turbines, performance testing of turbines at sight; Causes and impact of cavitation, silt erosion and their combined effect on operation of hydro turbines; Erection, commissioning, operation and maintenance of turbines.

**Text/Reference Book/Literature:**
<table>
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<th>Subject Name: Energy Transmission Technology</th>
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**Module 1: [10L]**
Introduction to DC-DC converter, Control strategies, Types of DC choppers and its classification, Brief idea about Buck, Boost and Buck-Boost chopper. Introduction to inverters, Classification of inverters, Principle of operation of single phase and three phase bridge inverter with R and R-L loads.

**Module 2: [10L]**

**Module 3: [10L]**

**Module 4: [10L]**
**Transmission System:** Short, Medium (nominal T and π) and Long transmission lines (equivalent T and π) and their representation. ABCD constants. Concept of HVAC-HVDC transmission system.

**Text/ Reference Book:**
1. Elements of power system analysis, C.L. Wadhwa, New Age International
2. Electrical Power System, Ashfaq Hussain, CBS Publishers & Distributors
3. Power Electronics, P.S Bimbhra, Khanna Publishers
Module 1: [10L]

Module 2: [10L]

Module 3: [10L]

Module 4: [10L]
Text/ Reference Book/ Literature:

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1. Study on thermal performance and efficiency of biomass downdraft gasifier;
2. Sampling and analysis of air and flue gas from biomass energy systems (i.e. gasifier, combustor and cook stoves) using gas chromatography technique;
3. Biogas production by anaerobic digestion and analysis;
4. Fuel Cell operation and electrical power generation;
5. Wind Tunnel: Pressure distribution analysis;
6. Performance analysis of an Electrical Inverter
7. Measurement of power factor and load characteristics of Power generator
8. Air conditioning performance test
9. Refrigeration performance test & COP measurement
10. Step-up and step-down Transformer Characteristics
SESSIONAL
Each student shall be required under the supervision of a faculty/ joint supervision of a faculty and an external expert to prepare a project work after carrying out investigation on an industrial research problem. The research work has to be carried out by the student himself occasionally consulting his supervisor(s). The work has to be allotted to the student at the beginning of the 3rd semester indicating the work to be carried out by the student. The report in duplicate has to be submitted in typed and bound form 7 days before commencement of the 3rd semester examination. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and the supervisor and an external examiner with Head of the Department as Chairman during 3rd Semester examination.
Semester IV
SESSIONAL
Subject Name: Thesis Part-II

Paper Code: REEN6221

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Each student shall be required under the supervision of a faculty / joint supervision of a faculty and an external expert to prepare a project work after carrying out investigation on an industrial research problem. The research work has to be carried out by the student himself occasionally consulting his supervisor(s). The work has to be allotted to the student at the beginning of the 3rd semester indicating the work to be carried out by the student. The report in duplicate has to be submitted in typed and bound form 7 days before the commencement of the 4th semester examination. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and the supervisor and an external examiner with Head of the Department as Chairman during 4th Semester examination.
This is a Viva – Voce examination to ascertain the student’s overall grasp of the principles of Renewable energy engineering and allied subjects. Assessment would be made on the basis of the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of three faculty members with Head of the Department as Chairman along with one external examiner during 4th Semester examination.